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# EVALUATION OF TWO SKID-MOUNTED CORE DRILLS FOR AIRFIELD PAVEMENT EVALUATION

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Two commercial skid-mounted core drills were evaluated for use by Air Force pavement evaluation teams. AFRL evaluated the drills for their ability to be mounted on a mobile platform (water requirements, power requirements, stability, etc.), and performed benchmark testing of the two drills on concrete pavements. No modifications to the commercial off-the-shelf rigs were made by the laboratory. Both drills were found to be functional with a cutting rate and depth potential compatible to other units of their size. Plumbing the drills was problematic. The drills tended to bind in the pavement during coring. Neither drill is recommended for use by the Air Force evaluation teams on small utility vehicles (including pickup trucks, panel vans, or other equivalent-sized vehicles) for contingency pavement evaluations.

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## Executive Summary

Two commercial skid-mounted core drills were evaluated for use by Air Force pavement evaluation teams. A skid-mounted core rig should be highly portable, easily shipped on Air Force cargo planes, and could be placed in the bed of a small utility vehicle. The two core drills included a hydraulic motor-powered drill and an electric motor-powered drill. AFRL procured the two core drills, evaluated their ability to be mounted on a mobile platform (water requirements, power requirements, stability, etc.), and performed benchmark testing on concrete pavements. No modifications to the commercial off-the-shelf rigs were made by the laboratory. Both of the drills appear to have been assembled by the vendor from third-party components.

Both drills were individually placed in a small utility vehicle. Evaluation consisted of using 2-, 4-, and 6-inch diameter core barrels on each drill. The time required to cut the cores was recorded along with the quantity of water used. Performance observations were made by AFRL technicians who are experienced operators familiar with the requirements of the Air Force pavement evaluations.

Both the electric and hydraulic drills were found to be functional with a cutting rate and depth potential compatible to other units of their size. Plumbing the drills was problematic. Skilled operators found that the drills tended to bind in the pavement during coring. This binding resulted from a slight change in angle of the drill shaft as downward pressure was applied to the drill. The binding resulted in a complete stall in cutting until the drill could be plumbed again or moved to a different location. This problem was exacerbated by the fact that the drills are light in weight, and small vehicle suspensions are sensitive to small changes in load. If the drill shaft is not plumb, the barrel will not cut properly, and the potential for catastrophic failure of the shaft exists.

Neither the electric or hydraulic drill is recommended for use by Air Force evaluation teams as currently configured. Vehicle outrigger stabilizers capable of lifting the tires completely off the ground and/or tracked vehicles are required for safe operation of the drills. A guide similar to the ones on larger core drills may eliminate drill wobble during the initial cutting sequence. However, the additional mass and cube may be problematic in maintaining the small logistical footprint for transport on military cargo aircraft.

# 1. Introduction

## 1.1. Background

AFCESA, APE Teams (as well as major command [MAJCOM] units) obtain, compile, and report pavement strength and performance data on all airfields with current or potential use by the U.S Air Force. Pavement evaluation data provides operations and civil engineer functions with airfield pavement information that can be used to manage and control an airfield system. The field work may consist of the following major elements:

- pavement inspection
- pavement coring
- Sampling or testing with heavy weight deflectometer (HWD), electronic cone penetrometer (ECP), and/or dynamic cone penetrometer (DCP) operations.

To perform a thorough evaluation, a team typically drills to extract at least one core from each airfield feature. Cores are used to verify pavement thickness and provide access to the pavement foundation for sampling and testing. A many as 150 to 200 cores can be required at a typical airbase. The pavement coring and patching operation requires 15 to 60 minutes per core location. A typical core drill may be trailer-mounted or truck-mounted and requires significant logistical support to move from location to location.

AFCESA funded the Air Force Research Laboratory (AFRL) to evaluate two commercial skid-mounted core drills. A skid-mounted core drill should be highly portable, easily shipped on Air Force cargo planes, and capable of being placed in the bed of a small utility vehicle.

The two drills tested included a hydraulic motor-powered drill (Figure 1) and an electric motor-powered drill (Figure 2), each of which are shown placed in the cargo bed of a small utility vehicle.

## 1.2. Objective

The objective of this study was to evaluate the utility of the two core drills for potential use by the APE team for use in contingency pavement evaluations.

## 1.3. Scope

AFRL procured the two core drills, evaluated their ability to be mounted on a mobile platform (water requirements, power requirements, stability, etc.), and performed benchmark testing of the two drills on test pavements at Tyndall AFB. This report provides documentation of the testing performed.


*Figure 1. Hydraulic Motor-Powered Core Drill*


*Figure 2. Electric Motor-Powered Coring Drill*

## 2. Core Drill Description

AFRL purchased both the electric and hydraulic drills from a commercial vendor. The drills are marketed under the name "Slider Core Rigs." No modifications to the commercial off-the-shelf products were made by the laboratory.

Both of the drills appear to have been assembled by the vendor from third-party components. There were no model numbers on either drill. Both the electric and hydraulic motors carry inscriptions that state they were made in Germany, but neither has manufacturer's information on the pump.

The electric drill requires 110-volt alternating current (AC) power, and the unit contains its own gasoline-powered Yamaha generator. No external power source was required for the electric drill and its water pump.

The hydraulic drill motor was powered by a Hydatech hydraulic pump model number HT20G. The hydraulic pump was driven by an electric motor powered by a Honda generator. However, there was no on-board source of power to operate the water pump, and auxiliary 110-volt electric power from a portable generator was required to operate the water pump.

Both drills have water tanks fabricated by Ace Roto-Mold Tanks, Inc. The electric core drill's tank had a water capacity of 55 gals, while the hydraulic drill's tank had a capacity of 70 gals.

# 3. Evaluation Procedures

Both drills were individually placed in a small utility vehicle as shown in Figures 1 and 2. From the outset of the project, AFRL planned to evaluate the drills using a small pickup truck as the platform. However, the units were too wide to fit between the pickup's wheel wells. AFRL chose the smallest vehicle available at the laboratory that contained sufficient cargo space to handle the footprint of the drills.

All excavations were conducted on a jointed, unreinforced Portland cement concrete pavement at the 9700 Area of Tyndall AFB, FL. The primary pavement was approximately 20 years old at the time of the experiment. The pavement consisted of 10-ft square slabs approximately 12 inches thick. The slabs were supported by a dense-graded limestone subbase which overlies a poorly graded (beach) sand subgrade. The aggregate in the concrete was crushed siliceous river gravel, and the compressive strength of the concrete averaged 8260 psi.

A second test pavement consisted of an 8-inch-thick patched area in the concrete pavement at the 9700 Area. The concrete was approximately 60 days old at the time of testing and had a compressive strength estimated at 4500 psi.

Evaluation consisted of using 2-, 4-, and 6-inch diameter core barrels on each drill. The time required to cut the cores was recorded along with the quantity of water used. Figure 3 shows an example photograph of the hydraulic drill with a 6-inch-diameter core barrel. Performance observations were made by AFRL technicians who are experienced operators familiar with the requirements of the APE Teams. Figure 4 shows a technician cutting a core with the electric drill.


*Figure 3. Hydraulic Drill with 6-Inch-Diameter Core Barrel*


*Figure 4. Technician Cutting a 2-Inch-Diameter Core with Hydraulic Drill*

## 4. Quantitative Evaluation

Table 1 presents the data recorded during the drill evaluations. Figure 5 and Figure 6 show plots of the drill penetration rate and water usage rates, respectively, for both the electric and hydraulic drills. The data in Figure 5 indicate that the hydraulic and electric drills are approximately equivalent in rate of penetration. Figure 5 also illustrates that there is considerably more variability in rate of penetration for the 2-inch-diameter core barrel than for the 4- or 6-inch diameter barrels. The water usage rates in Figure 6 show that both drills are similar in that regard.

Both drills performed similarly in like situations. No change in cutting rate was noted with depth. However, larger core barrels as well as pavement hardness slow the cutting speed.

*Table 1. Evaluation Results*

| Pavement thickness / approximate age | Core barrel diameter size | Cutting depth | Cutting time | Water usage |
|---|---|---|---|---|
| Electric drill | | | | |
| 12 in. / > 20 yrs | 2 in. | Full depth | 5 min, 0 sec | 12 gals |
| 12 in, / > 20 yrs | 2 in. | Full depth | 10 min, 17 sec | 18 gals |
| 8 in. / 60 days | 2 in. | Full depth | 1 min, 39 sec | 5 gals |
| 12 in. / > 20 yrs | 4 in. | Full depth | 20 min, 0 sec | 32 gals |
| 8 in. / 60 days | 4 in. | Full depth | 13 min, 16 sec | 25 gals |
| 12 in. / > 20 yrs | 6 in. | 1 ½ in penetration | 21 min, 10 sec | 32 gals |
| 8 in. / 60 days | 6 in. | Full depth | 10 min, 36 sec | 28 gals |
| Hydraulic drill | | | | |
| 12 in. / > 20 yrs | 2 in. | Full depth | 14 min, 33 sec | 10 gals |
| 12 in. / > 20 yrs | 2 in. | Full depth | 24 min, 50 sec | 15 gals |
| 8 in. / 60 days | 2 in. | Full depth | 2 min, 4 sec | 5 gals |
| 12 in. / > 20 yrs | 4 in. | Full depth | 24 min, 33 sec | 40 gals |
| 8 in. / 60 days | 4 in. | Full depth | 10 min, 39 sec | 20 gals |
| 12 in. / > 20 yrs | 6 in. | 6 in penetration | 16 min, 43 sec | 30 gals |
| 8 in. / 60 days | 6 in. | Full depth | 34 min, 0 sec | 25 gals |

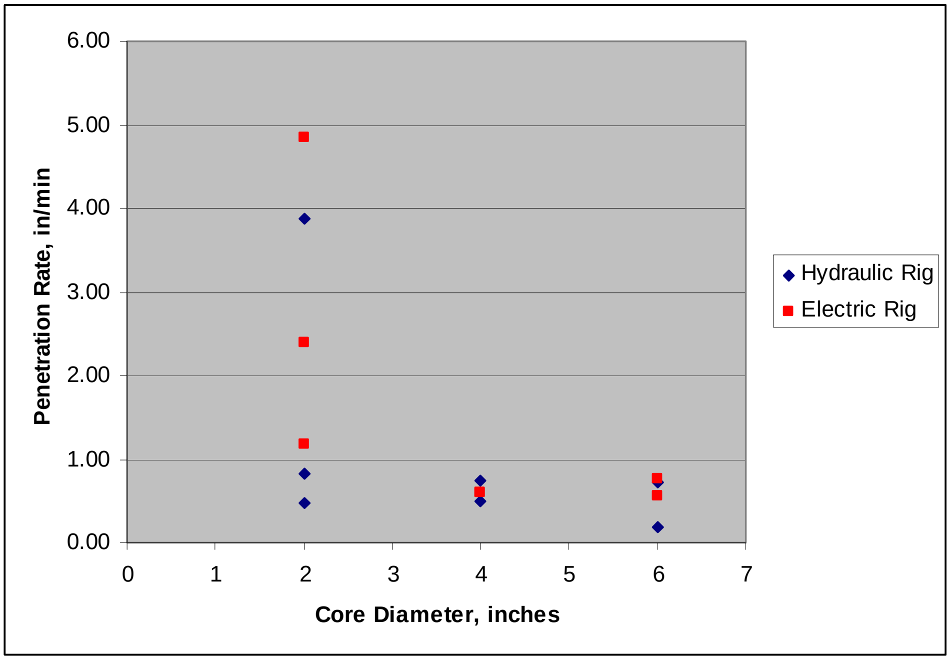


*Figure 5. Penetration Rates*

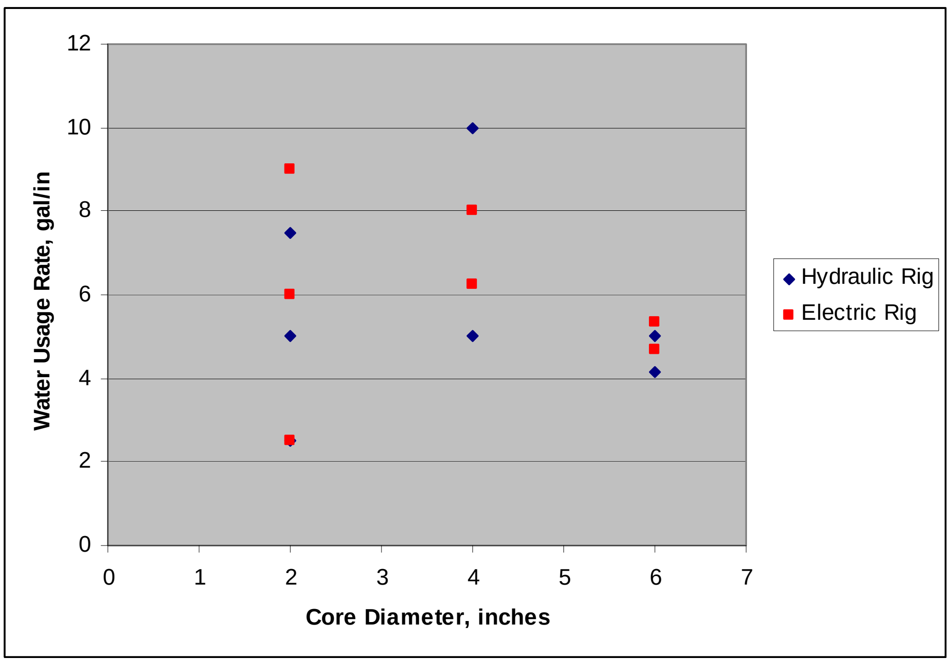


*Figure 6. Water Usage Rates*

# 5. Discussion

## 5.1. Cutting Rate

Both the electric and hydraulic drills were found to be functional with a cutting rate and depth compatible to other units of their size (based upon the experience of the operators). With the two drills evaluated (as with any core drill), cutting rate varies with the type and size of the core barrel and the hardness of the materials being cored. Core barrels are manufactured for certain RPM, dry or wet cut, and concrete or asphalt pavements. Material hardness will vary from location to location; thus, the operator will experience significant variability in cutting rate.

## 5.2. Water Usage

Water usage depends upon the same items as cutting rate. Availability of water is always an issue at any field operating base; however, coring operations only require a flowing stream approximate the diameter of a pencil. The goal is to provide sufficient water to maintain a paste-like consistency of the coring residue and not to flood the core.

## 5.3. Operation

The units exceed the 2-inch diameter requirement established by AFCESA for dynamic cone penetrometer (DCP) operations and obtaining pavement thickness.

Starting at slower speeds initially, then increasing the speed while drilling eliminates vibration and provides a smoother cut. The hydraulic drill speed can be adjusted from slow to higher speeds while drilling. The electric drill has three speeds but must be stopped prior to changing speeds. Both drill units were found to be stable; however, larger cutting barrels (six inch diameter) wobble when initial cut is made

Minor maintenance tasks could be performed by an experienced operator on either unit.

Both drills and adjoining shafts must be carefully plumbed prior to operation. ***This step is critical for safe operation of the units. If the drill shaft is not plumb, the barrel will not cut properly, and the potential for catastrophic failure of the shaft exists.*** AFRL technicians broke the shaft on the first series of testing resulting in life-threatening conditions and complete failure of the machine. The operator must check plumb at each core location. Two individuals are required to perform this--one to hold a one-foot-long level and the other to adjust the alignment bolts. Figure 7 shows a photograph of operators improvising by using a wooden plank to keep the drill plumb while starting a core.

The operators found that the drills could be easily bound as the coring proceeded deeper into the pavement. This binding occurred as the downward pressure on the drill increased during coring resulting in more upward force on the skid-mounted drill thus unloading the suspension of the vehicle. The result was a slight change in angle of the drill shaft—enough to cause the core saw to bind in the pavement. This problem is exacerbated by the fact that the drills are light in weight, and the vehicle suspensions are sensitive to small changes in load. This action will occur anytime the downward pressure is increased more than the capability of the machine and/or hardness of concrete.

In an attempt to overcome this problem, AFRL mounted the hydraulic drill in panel van (approximately equivalent in weight to a pickup truck).  The same problems were encountered; as the drilling proceeded, the force of the drilling began to lift the van, and the drill bound in the pavement.

*Figure 7. Operators Using Lumber Plank to Keep Drill Plumb while Starting Core*

# 6. Conclusions and Recommendations

## 6.1. Conclusions

1. Two skid-mounted core drills, one hydraulic and one electric, were evaluated for use by the APE team for operations related to pavement evaluations. The core drills are highly portable, easily shipped on Air Force cargo planes, and can fit in the bed of a small utility vehicle. The units are self-contained with water tanks and on-board power provided by small gasoline engines. One exception is the pump for the hydraulic drill, which required a small 110 volt AC auxiliary generator.
2. Both the electric and hydraulic drills were found to be functional with a cutting rate and depth potential compatible to other units of their size under ideal conditions.
3. Plumbing the drills was problematic. Skilled operators found that the drills tended to bind in the pavement during coring. This binding resulted from a slight change in angle of the drill shaft as downward pressure was applied to the drill. The binding resulted in a complete stall in cutting until the drill could be plumbed again or moved to a different location. This problem was exacerbated by the fact that the drills are light in weight, and small vehicle suspensions are sensitive to small changes in load.
4. Starting at slower speeds initially, then increasing the speed while drilling eliminates vibration and provides a smoother cut.

## 6.2. Recommendations

1. Operators should receive thorough training and comprehend all capabilities and associated hazards during operation of the drills.
2. Operators must carefully check plumb at each core location. Two individuals are required to perform this--one to hold a one-foot-long level and the other to adjust the alignment bolts. ***If the drill shaft is not plumb, the barrel will not cut properly, and the potential for catastrophic failure of the shaft exists.***
3. Neither the electric or hydraulic drill is recommended for use by the APE teams on small utility vehicles (including pickup trucks, panel vans, or other equivalent-sized vehicles) for contingency pavement evaluations as currently configured.
4. Vehicle outrigger stabilizers capable of lifting the tires completely off the ground and/or tracked vehicles are required for safe operation of the drills.

5. A guide similar to the ones on larger core drills may eliminate the wobble during the initial cutting sequence. However, the additional mass and cube may be problematic in maintaining the small logistical footprint for transport on military cargo aircraft.